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## Space Weather Technical Forecast

Issued on Wednesday 18 December 2024 at 12:23 Local

**This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>**

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**Space Weather Forecast Headline: Chance of M-class flares (R1-R2; Minor-Moderate radio blackouts) throughout.**

### Analysis of Space Weather Activity over past 24 hours

**Solar Activity:** Low, with a peak C8.2 flare at 18/0734 UTC, which is probably from the southeast limb. There are eight sunspot regions on the Earth-facing disc. AR3924 (Eho/Beta-Gamma) remains the most complex sunspot group on the disc, but the region has shown stability. AR3922 (Dai/Beta-Gamma) has shown the most recent development but again, remains stable at present. Some CME eruptions were observed off the East limb early on the 17 Dec, unlikely to be Earth-directed, followed by a notable halo CME at 17/1600 UTC. From analysis this looks most likely to be far-sided with limited impact to Earth.

**Solar Wind / Geomagnetic Activity:** Solar winds, as observed by ACE and DSCOVR at L1, showed started the period at Strong levels following arrival of a CME at 17/0437 UTC. Solar winds peaked at 700km/s around 17/0900 UTC are now at Elevated levels at 500km/s. Density started at above or well above average levels, around 50ppcc and have now dropped to below average. The Interplanetary Magnetic Field (IMF), Bt, was initially at Strong and is now Weak. The north-south component, Bz, was largely positive before becoming moderately negative for a time, and is now at weak levels. The phi angle was predominantly negative (towards the Sun). Geomagnetic activity started at Active levels (Kp4) and is now Quiet to Unsettled (Kp2-3).

**Energetic Particles / Solar Radiation:** High energy proton flux observed by GOES18 was at background levels. A peak in proton flux was observed at 17/1915 UTC believed to be related to the significant far-sided halo CME. High energy electron flux (greater than 2MeV) observed by GOES16 was background. The associated 24-hour fluence was well below the Active (1e8 integrated flux) threshold. The 18/0000 UTC observation was 1.27e6 integrated pfu.

### Four-Day Space Weather Forecast Summary

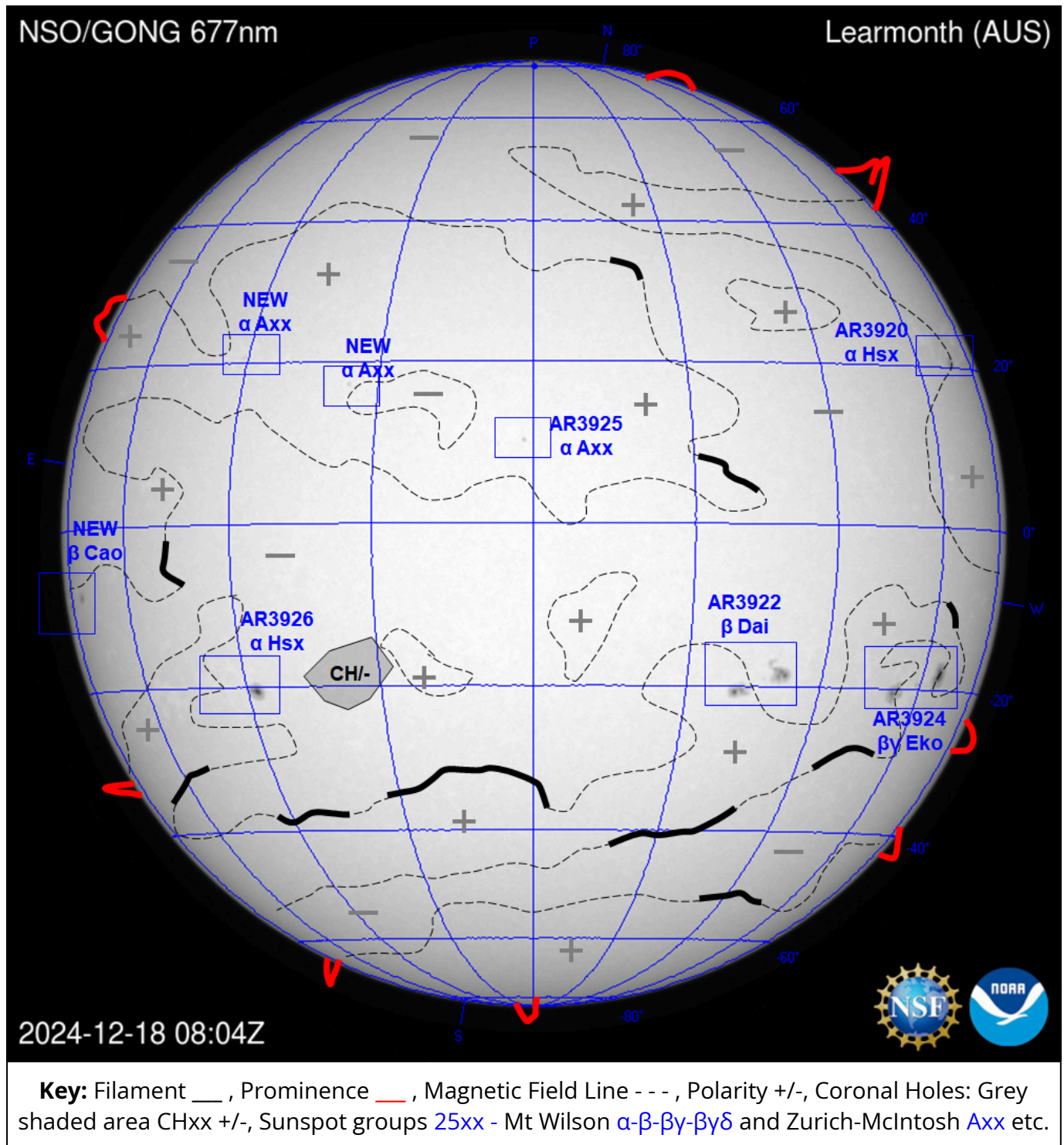
**Solar Activity:** Low to Moderate Solar activity is forecast with a chance of M-class flares, increasing gradually through the forecast period.

**Solar Wind / Geomagnetic Activity:** The CME experienced at Earth during the morning of 17 Dec is likely has now largely waned with Quiet to Unsettled (Kp1-3) conditions. Several other CMEs that left the Sun in the past few days are forecast as near misses, but cannot be completely ruled out

as flanking arrivals at Earth, so there is some uncertainty in the forecast currently. Active intervals (Kp4) are most likely at first during day 1 (18 Dec

**Energetic Particles / Solar Radiation:** High energy proton flux is expected to remain at background, but carries a slight chance of reaching S1/Minor Storm levels or greater, in response to any notable solar flares. High energy electron flux may increase to moderate with diurnal peaks of high. However, the 24-hour fluence is expected to remain below the Active threshold throughout.

Figure 1: Solar Synoptic Map valid 18/0800 UTC



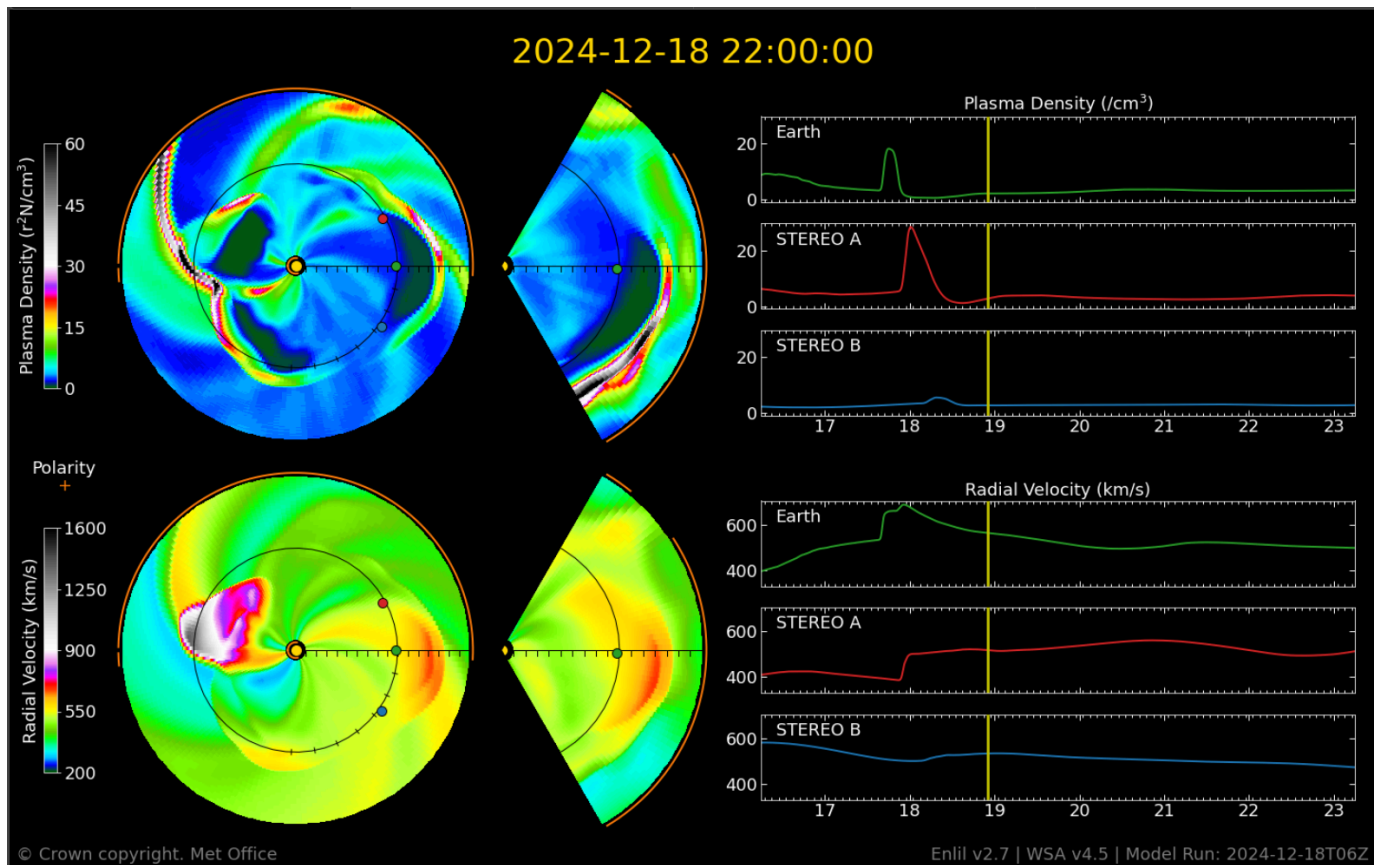
## Geomagnetic Storms

The unexpected CME which arrived at Earth early on the 17 Dec is thought to be associated with a large and complex filament eruption that occurred early on the 15 Dec. Most of the ejecta from the filament appeared to go south and west out of the solar system and away from Earth, but there was evidence of a very faint and fast shock front emanating from the Sun shortly afterwards, as seen only on STEREO A coronagraph. Solar winds remain elevated at around 500km/s. A gradual decline is anticipated over the next couple of days to slightly elevated levels and by Day 3 (20Dec) will probably be at Slow-Ambient levels. Geomagnetic activity is now at Quiet to Unsettled (Kp1-3) levels. Any previous estimations of CME arrivals are likely to have been swept up and are no longer forecast to have any impact on Earth.

A halo CME was evident in Lasco imagery around 17/1600 UTC, however this appears to be farsided with minimal impact to Earth currently expected. There have been no further significant CMEs observed in the Earth-Sun line. A few other filaments have also erupted early on the 17 Dec, but are not thought to be Earth-directed. No significant coronal holes are expected to influence the forecast period, however there are signs of a weak coronal hole on GOES-16 SUVI imagery which may assist in keeping solar winds at slightly elevated levels.

| Geomagnetic Storm           | Level    | Past 24 Hours<br>(Yes/No) | Day 1<br>(00-24 UTC) | Day 2<br>(00-24 UTC) | Day 3<br>(00-24 UTC) | Day 4<br>(00-24 UTC) |
|-----------------------------|----------|---------------------------|----------------------|----------------------|----------------------|----------------------|
| Probability<br>(Exceedance) |          |                           | (%)                  | (%)                  | (%)                  | (%)                  |
| Minor or Moderate           | G1 to G2 | No                        | 10                   | 5                    | 5                    | 5                    |
| Strong                      | G3       | No                        | 1                    | 1                    | 1                    | 1                    |
| Severe                      | G4       | No                        | 1                    | 1                    | 1                    | 1                    |
| Extreme                     | G5       | No                        | 1                    | 1                    | 1                    | 1                    |

**Figure 2: Latest Met Office ENLIL output, with ntable CME directed away from Earth.**



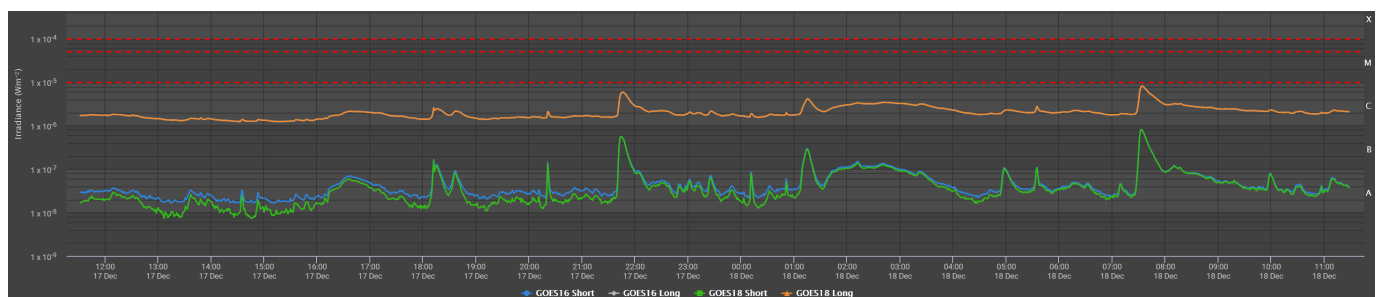
## Radio Blackouts - X-Ray Flares

Eight sunspot regions cover the disc. AR3924 in the southwest is the largest and most complex region, consisting of a large, symmetric leading spot and a smaller, more irregularly shaped trail spot. AR3922 is the second largest with recent emergence of intermediate spots. The remaining regions on the disc are smaller and more magnetically simple. A new, unnumbered region rotating around the southeast limb is showing signs of some complexity. Solar activity is Low. More sunspots are expected to rotate around the limb during the next few days, with a history of flaring, so the chances of M-flares increases with time as shown in the table below. The first of which is beginning to show coming around the southeast limb and probably produced the largest flare of the past 24 hours, a C8.2 flare at 18/0734 UTC.

There continues to be the likelihood for further regions to rotate onto the disc from over the east limb between Days 1 and 2 (18-19 Dec) corresponding to Ex-AR3902, Ex-AR3905 and Ex-AR3906. The latter two produced M-class flares when they were last on the facing-disc and recent far-sided CME activity and helio-seismic soundings suggest that at least one of these regions remains active.

| X-Ray Flares | Level              | Past 24 Hours<br>(Yes/No) | Day 1<br>(00-24 UTC) | Day 2<br>(00-24 UTC) | Day 3<br>(00-24 UTC) | Day 4<br>(00-24 UTC) |
|--------------|--------------------|---------------------------|----------------------|----------------------|----------------------|----------------------|
| Probability  |                    |                           | (%)                  | (%)                  | (%)                  | (%)                  |
| Active       | R1-R2<br>(M Class) | No                        | 30                   | 40                   | 60                   | 60                   |
| Very Active  | R3-R5<br>(X Class) | No                        | 1                    | 5                    | 5                    | 5                    |

**Figure 3: Latest X-ray flux at GEO from GOES data, with numerous C-class flares.**

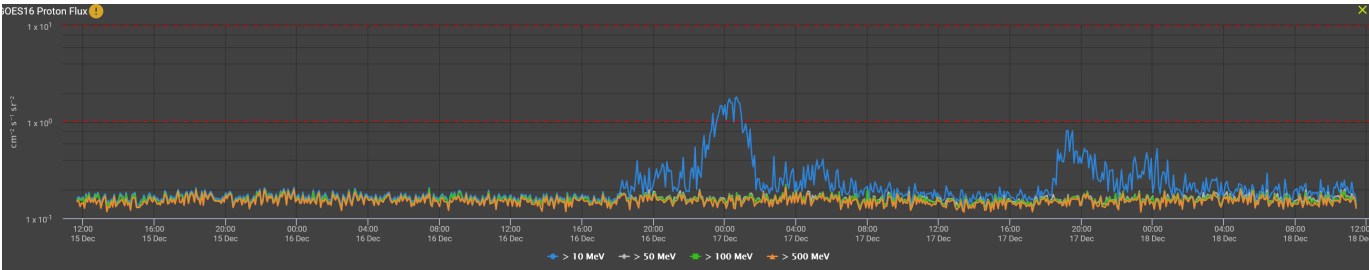


Solar Radiation Storms (High Energy Protons)

GOES18 proton flux is at background levels. There is a continuing slight chance of reaching S1/Minor Storm levels or greater, in response to any notable solar flares, currently most likely from AR3924. This region will likely rotate over the western horizon on Day 3 (20 Dec), but proton storm probabilities are maintained for at least 24-hours after it leaves the visible disc.

| Radiation Storms                                                                                           | Level<br>(cm <sup>-2</sup> sr <sup>-1</sup> s <sup>-1</sup> ) | Past 24 Hours<br>(Yes/No) | Day 1<br>(00-24 UTC) | Day 2<br>(00-24 UTC) | Day 3<br>(00-24 UTC) | Day 4<br>(00-24 UTC) |
|------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|---------------------------|----------------------|----------------------|----------------------|----------------------|
| Probability<br>(Exceedance)                                                                                |                                                               |                           | (%)                  | (%)                  | (%)                  | (%)                  |
| Active                                                                                                     | ≥ S1                                                          | No                        | 10                   | 15                   | 15                   | 15                   |
| Very Active                                                                                                | ≥ S3 *                                                        | No                        | 1                    | 1                    | 1                    | 1                    |
| * S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = cm <sup>-2</sup> sr <sup>-1</sup> s <sup>-1</sup> ) |                                                               |                           |                      |                      |                      |                      |

Figure 4: Proton flux at GEO from GOES data with minor enhancements noted following recent CME and flare activity.



High Energy Electrons (≥ 2MeV)

High energy electron flux observed by GOES16 has been at largely background levels following the influence of the recent CME arrival causing the electron belts to become compressed away from GEO. However, as the Van Allen belt relaxes and expands back towards GEO in the coming days the electron flux at GEO may rise to moderate, perhaps peaking a high levels within the diurnal cycle.

The associated 24-hour fluence will probably remain below the Active (1e8 integrated flux) threshold throughout the forecast period. MOSWOC REFM output is considered to be providing good guidance.

| GEO Electron Environment    | Level<br>(cm <sup>-2</sup> sr <sup>-1</sup><br>day <sup>-1</sup> ) | Past 24 Hours<br>(Yes/No) | Day 1<br>(00-24 UTC) | Day 2<br>(00-24 UTC) | Day 3<br>(00-24 UTC) | Day 4<br>(00-24 UTC) |
|-----------------------------|--------------------------------------------------------------------|---------------------------|----------------------|----------------------|----------------------|----------------------|
| Probability<br>(Exceedance) |                                                                    |                           | (%)                  | (%)                  | (%)                  | (%)                  |
| Active                      | ≥ 2 MeV<br>≥ 1×10 <sup>8</sup>                                     | No                        | 1                    | 1                    | 10                   | 10                   |
| Very Active                 | ≥ 2 MeV<br>≥ 1×10 <sup>9</sup>                                     | No                        | 1                    | 1                    | 1                    | 1                    |

**Figure 5: MOSWOC REFM output (lower) and high energy electron flux at GEO (upper).**

